Impact of TNAU-Water Soluble Fertilizers (TNAU-WSF) on Soil Nutrient Availability, Nutrient Content and Bulb Quality of Small Onion (*Allium cepa* var. *aggregatum*)

ABSTRACT

Application of highly sustainable and productive inputs is required to increase food production in order to feed the growing world population while using the same amount of land. Thus, in its very first attempt, the Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu, has produced water soluble fertilisers (WSF) named as TNAU-Water Soluble Fertilizers (TNAU-WSF), and it is necessary to optimise on various crops. One of the most essential vegetables in Indian cuisine is the small onion, which has a high demand but a low productivity. The use of TNAU-WSF was initiated to improve small onion crop productivity and quality. Eight treatments were incorporated in a field experiment that was set up using a Randomised block design (RBD), including the application of RDF at 100% NPK as TNAU WSF, soil test-based applications (STB) of 75%, 100%, and 125% NPK ha^{-1} as TNAU-WSF, with and without sulphur (S) and TNAU liquid multi micronutrient (TNAU LMM) and the absolute control. With small onion (CO 4), each treatment was replicated three times. Soil test based application of higher nutrient level (125% NPK) recorded higher nutrient availability, plant nutrient content and enhanced bulb quality (crude protein and total sugars) of small onion. The correlation study revealed that treatments with higher nutrient availability had a high impact on nutrient content and bulb quality of small onion.

Key words: TNAU-WSF, Fertigation, TNAU LMM, Small Onion, Soil Test Based Application

1. INTRODUCTION

Ever growing increase in world population needs higher food production per unit land area. To enhance the crop productivity and meet out the demand, farmers apply higher amount of fertilizers that cause environmental risks [1]. Hence, the production technologies and inputs should be applied in a sustainable way to meet out the demand in future. Water scarcity is also an evolving problem that may be solved in a judicious way to reduce the unnecessary loss of water [2].

Fertigation is a promising solution to save the amount of water [3] and reduce nutrient loss [4] and thus can increase the yield of crop [5] compared to surface irrigation. In this context, the Department of Soil Science and Agricultural Chemistry (SS & AC), Tamil Nadu Agricultural University (TNAU) in its maiden attempt has synthesized a Water Soluble Fertilizer *viz*., Tamil Nadu Agricultural University – Water Soluble Fertilizer (TNAU-WSF) @ 19:19:19 % NPK. The present study was undertaken to evaluate the efficacy of newly synthesized TNAU-WSF on small onion and to optimize the level of TNAU-WSF for fertigation. Small onion decreases the risk of cardiovascular [6] and metabolic diseases including hyperlipidemia, atherosclerosis, thrombosis, diabetes, and hypertension [7]. The average productivity of onion in India is low than world average productivity [8]. Hence the TNAU-WSF was evaluated for fertigation with small onion as test crop.

The results obtained from the effect of different nutrient levels of TNAU-WSF with sulphur and TNAU-Multi micronutrient (TNAU-LMM) on nutrient content and bulb quality of small onion and soil available nutrients (N, P, K, S, and micronutrients) will be discussed.

2. MATERIAL AND METHODS

The field experiment was conducted in a farmer's field at Devarayapuram village, Thondamuthur block, Coimbatore district during 2020-21. The site was geographically situated at 11^{o} 01´N latitude, 76^{o} 8´ E longitude, with an altitude of 315m above mean sea level (MSL). Experimental site had mean annual rainfall of 952 mm and average minimum and maximum temperatures were 17^{o} C and 38^{o} C. Maximum rainfall was received between October to December [9].

The raised beds were formed manually with the length of 5 m and breadth of 4m forming an area of 20 m^2 plot. The experiment was laid out in Randomized Block Design (RBD) with eight treatments replicated thrice viz, T1: Recommended Dose of Fertilizers (RDF) @100% NPK as TNAU-WSF, T2: Soil test based (STB) fertigation of 75% NPK as TNAU-WSF, T3: STB of 100% NPK as TNAU-WSF, T4: STB of 125% NPK as TNAU-WSF, T5: STB of 75% NPK as TNAU-WSF + Sulphur (S) @ 40 kg ha-1 + Foliar Spray (FS) of TNAU LMM @ 1%, T6: STB of 100% NPK as TNAU-WSF + S @ 40 kg ha-1 + TNAU LMM @ 1% FS, T7: STB of 125% NPK as TNAU-WSF + S @ 40 kg ha -1 + TNAU LMM @ 1% FS, T8: Absolute control.

The soil samples were collected before and after harvest and during different stages of crop growth. The collected soil samples were air dried, ground with wooden mallet and sieved through 2 mm sieve and stored for further analysis. The samples were analysed in accordance with the standard procedure for available N, P, K, S, and micronutrients as Alkaline $KMnO_4$ method [10], Olsen reagent method [11], Neutral Normal ammonium acetate [12], Turbidimetry method [13], and DTPA method [14], respectively.

The soil of the experimental site was sandy loam. The soil is neutral in reaction with a pH of 7.18, non saline with a EC of 0.25 dS m^{-1} and non- calcareous in nature. The available N, P, K and S in soil were low (155 kg ha^{-1}), high (39 kg ha^{-1}), medium (210 kg ha^{-1}) and medium (14 mg kg^{-1}) status, respectively. The DTPA Zn (0.68 mg kg^{-1}) and Cu (0.48 mg kg^{-1}) were deficient and was corrected with the application of 25 kg $ZnSO_4$ ha^{-1} and 2.5 kg $CuSO_4$ ha^{-1}. DTPA Fe (6.91 mg kg^{-1}) and Mn (5.38 mg kg^{-1}) were sufficient in soil. TNAU-WSF was applied through fertigation according to fertigation schedule mentioned in crop production guide [15]. The dose of NPK was generated based on soil test fertilizer prescription equations (FPE) for small onion as given in crop production guide (CPG) – Horticulture, 2020. Sulphur was applied at 40 kg ha^{-1} at 30 DAS and TNAU LMM at 1% sprayed thrice at 30, 40, 50 DAS. The total macronutrients, viz., N, P, and K, content of small onions were analysed with the methods of micro-kjeldahl [16], Vanadomolybdate yellow colour method [17], and Flame photometer [17], respectively, and total S [13], total micronutrients [14]. Crude protein of small onion bulbs was calculated by multiplying the total nitrogen content of small onion with 6.25. Total sugars content of bulbs was estimated according to method mentioned by [18].

2.1 Statistical analysis

The analysis of variance for sets of data on available nutrient and bulb quality with significance level (P = .05) was done with AGRES software. The least square different (LSD) was used to separate the significantly differed mean. A correlation between available nutrients in soil and bulb quality parameters were worked out to assess the response of small onion to fertigation of TNAU-WSF with MS-Excel.

3. RESULT AND DISCUSSION

3.1 Soil available NPK

Soil test based application of 125% NPK with sulphur (S) and TNAU LMM (T_7) recorded higher available NPK (Table 1) at 30, 60, and 90 days after sowing (DAS) and was on par with fertigation of TNAU-WSF at 125% NPK (T_4). Low soil availability of NPK was recorded in absolute control plot (T_8). Higher soil available nitrogen, phosphorus, and potassium were observed due to higher doses of NPK with TNAU-WSF and split application through 125% NPK [19], [20]. Nutrient availability declined over a period of crop growth. In vegetative stage of crop growth, availability of nutrients (N, P, K) in soil was higher than bulb formation and post-harvest stage because of enhanced crop growth and continuous crop removal of nutrients over a period of growth [21], [22]. Similar results, such as 150% NPK application, recorded higher nutrient availability, as reported by [23].

3.2 Soil available sulphur and micronutrients

The availability of sulphur (S) (Table 1) at 30 DAS was no difference in mean of treatments. Sulphur availability at 60 and 90 DAS was high in fertigation of TNAU-WSF at 75% (T_5), 100% (T_6), and 125% (T_7) NPK with sulphur and TNAU LMM (1%) than fertigation of TNAU-WSF at 75% (T_2), 100%

Table 1. Fertigation of TNAU-WSF on soil available NPK and S at different stages of small onion crop growth

T.No.	Available N (kg ha^{-1})			Available P (kg ha^{-1})			Available K (kg ha^{-1})			Available S (mg kg^{-1})		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	198	195	169	56	48	44	223	209	184	14.50	9.40	9.10
T_2	210	201	183	58	51	53	231	216	196	15.80	10.70	9.06
T_3	237	230	210	67	61	58	268	231	208	16.30	11.50	10.60
T_4	273	260	232	77	68	65	295	249	227	17.60	12.40	10.98
T_5	212	205	190	60	55	53	239	219	200	20.00	18.60	15.34
T_6	251	238	213	71	62	61	272	239	215	22.00	19.45	16.12
T_7	281	272	244	78	70	69	296	255	239	28.30	21.50	17.78
T_8	158	150	142	30	22	17	180	157	136	12.00	10.23	9.54
Mean	237.43	228.71	205.86	66.71	59.29	57.57	260.57	231.14	209.86	19.21	14.79	12.71
S.Ed	9.832	9.475	8.606	2.627	2.304	2.198	10.92	9.694	8.704	0.588	0.613	0.538
CD(P=0.05)	21.09	20.32	18.46	5.635	4.921	4.715	24.43	20.79	18.67	NS (11.76)	1.315	1.154

(T_3), and 125% (T_4) NPK which recorded low S availability. Higher availability of S was due to additional sulphur application [23] [24] [25]. Micronutrient availability showed non-significant differences between means of treatments because of no external application of micronutrients to soil [26].

3.3 Nutrient content of small onion

The nutrient content of small onions (Table 2) is highly dependent on soil available nutrients. The treatments with higher nutrient levels (125% NPK) (T_7, T_4) recorded higher nutrient content of NPK as it influences soil nutrient availability [27] [28] [29]. Lower nutrient content was recorded in the absolute control plot (T_8). In the case of the S content of small onions, those treatments receiving sulphur, such as T_7, T_6, and T_5, recorded higher S content in the bulbs and leaves [30]. The plots (T_7, T_6, and T_5) that received TNAU-LMM as a micronutrient source recorded higher micronutrient (Fe, Zn, Cu, and Mn) content (Table 3) in the bulb and leaves of small onions [22].

3.4 Bulb quality

Crude protein and total sugar content (Table 4) of small onion are influenced by different nutrient levels of TNAU-WSF. Higher nutrient levels of NPK (125%) recorded higher crude protein content and total sugars because of enhanced accumulation of photosynthates, viz., carbohydrates in the form of sugars and amino acids, in onion bulbs [31] [32] [33]. The increase in crude protein contents with increasing fertilizer levels may be the result of enhanced amino acid formation due to fertilization [34]. Application of sulphur to small onion had additive effect on bulb quality of small onion [35] [36]. Because sulphur amino acids such as methionine and cysteine, are essential to produce proteins and act as precursors of critical cofactors and metabolites [37]. Application of micronutrients through TNAU LMM has impacted total sugar content and crude protein in onion bulbs though enhancement of plant metabolism [38] [39] [40].

3.5 Correlation analysis

The correlation (Table 5) between soil available nutrients (NPK) and small onion's bulb quality was highly positive. Because of the higher nutrient availability achieved by higher nutrient level, which has directly affected the small onion's bulb quality. The increase in nutrient levels increased the bulb quality of small onions by improved plant uptake of nutrients. The correlation between soil available nutrients (NPK) and plant nutrient content (NPK) is represented in Figure 1. A highly positive correlation was shown between plant nutrient content and soil available nutrient through enhanced plant uptake.

Table 2. Fertigation of TNAU-WSF on total N, P, K, and S (%) content at different growth stages of small onion

T. No.	N				P				K				S			
	30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS	
											Bulb	Leaves			Bulb	Leaves
			Bulb	Leaves			Bulb	Leaves	1.84	1.99	1.56	0.54	0.34	0.39	0.33	0.26
T_1	2.06	2.18	1.88	0.51	0.38	0.42	0.30	0.12	2.03	2.14	1.69	0.68	0.35	0.40	0.33	0.28
T_2	2.12	2.25	1.89	0.54	0.41	0.48	0.35	0.13	2.29	2.38	1.84	0.88	0.37	0.40	0.39	0.30
T_3	2.21	2.36	2.11	0.58	0.46	0.54	0.39	0.15	2.38	2.42	2.19	0.92	0.38	0.41	0.44	0.31
T_4	2.34	2.48	2.18	0.61	0.52	0.68	0.45	0.16	2.16	2.29	1.87	0.70	0.39	0.43	0.45	0.32
T_5	2.18	2.32	1.91	0.56	0.43	0.52	0.38	0.13	2.45	2.51	1.97	0.90	0.41	0.46	0.45	0.36
T_6	2.34	2.45	2.19	0.59	0.51	0.61	0.43	0.17	2.52	2.61	2.28	0.95	0.42	0.48	0.46	0.37
T_7	2.41	2.58	2.25	0.63	0.69	0.72	0.54	0.19	1.47	1.66	1.42	0.41	0.30	0.37	0.30	0.21
T_8	1.82	1.98	1.43	0.49	0.31	0.37	0.25	0.09	0.092	0.099	0.081	0.030	0.011	0.169	0.016	0.010
Mean	2.19	2.33	1.98	0.56	0.46	0.54	0.39	0.14	1.92	2.01	1.67	0.67	0.33	0.39	0.31	0.27
S.Ed	0.097	0.103	0.087	0.026	0.020	0.023	0.017	0.006	0.198	0.213	0.173	0.070	NS	0.045	0.057	0.030
CD(P=0.05)	0.208	0.222	0.188	0.055	0.043	0.049	0.036	0.010	1.84	1.99	1.56	0.54	0.34	0.39	0.33	0.26

Table 3. Fertigation of TNAU-WSF on total micro nutrient content (mg kg^{-1}) at harvest stage of small onion

T.No.	Treatments	Total micronutrient content in bulbs (mg kg^{-1})				Total micronutrient content in leaves (mg kg^{-1})			
		Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
T_1	RDF @100% NPK as TNAU-WSF	280	147	29	11.24	189	125	22	8.25
T_2	STB of 75% NPK as TNAU-WSF	312	153	36	12.65	201	131	25	10.72
T_3	STB of 100% NPK as TNAU-WSF	301	167	41	14.28	213	134	26	11.85
T_4	STB of 125% NPK as TNAU-WSF	290	179	44	15.39	217	136	28	13.42
T_5	STB of 75% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	356	183	59	22.40	236	145	34	18.68
T_6	STB of 100% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	369	191	63	25.22	245	149	35	19.60
T_7	STB of 125% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	375	194	66	26.14	251	151	38	21.75
T_8	Absolute Control	268	136	21	8.36	160	119	17	7.45
Mean		326.14	173.43	48.29	18.19	221.71	138.71	29.71	14.90
S.Ed		18.11	11.44	4.183	1.962	14.85	21.62	9.12	7.81
CD(P=0.05)		37.43	28.62	7.827	3.951	32.15	39.31	18.74	16.91

RDF – Recommended dose of fertilizer, STB – Soil test based, S – Sulphur, FS Foliar spray

Table 4. Fertigation of TNAU-WSF on quality attributes of small onion

T.No.	Treatments	Crude protein (%)	Total sugar (mg g^{-1} FW)
T_1	RDF @100% NPK as TNAU-WSF	11.33	3.21
T_2	STB of 75% NPK as TNAU-WSF	11.74	3.46
T_3	STB of 100% NPK as TNAU-WSF	13.20	4.54
T_4	STB of 125% NPK as TNAU-WSF	14.92	5.57
T_5	STB of 75% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	11.94	3.67
T_6	STB of 100% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	13.69	4.74
T_7	STB of 125% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	15.33	5.91
T_8	Absolute Control	8.950	2.98
Mean		12.64	4.26
S.Ed		0.550	0.184
CD(P=.05)		1.179	0.394

RDF – Recommended dose of fertilizer, STB – Soil test based, S – Sulphur, FS Foliar spray

Table 5. Correlation between average soil available nutrient and onion quality parameter

	Available N	Available P	Available K	Crude protein	Total sugar
Available N	1				
Available P	0.999861361	1			
Available K	0.999615495	0.999831133	1		
Crude protein	0.99877448	0.998398705	0.997392869	1	
Total sugar	0.962735261	0.962077899	0.963789449	0.952935709	1

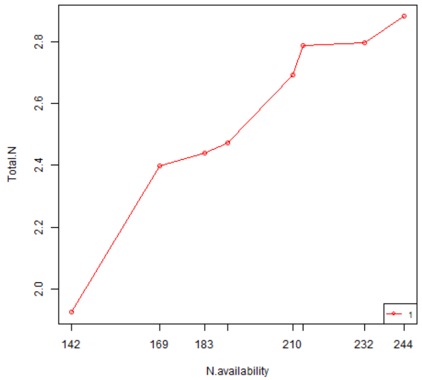

Fig. 1a. Correlation between soil N availability (kg ha^{-1}) and nutrient content in small onion (R^2 = 0.963)

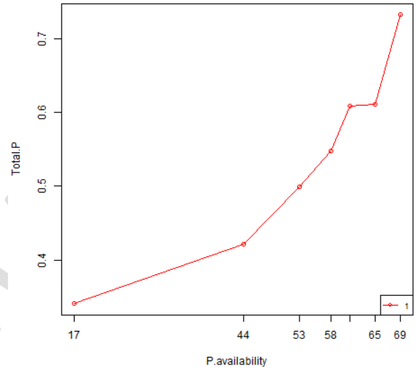

Fig.1b. Correlation of soil P availability (kg ha^{-1}) and nutrient content in small onion (R^2 = 0.964)

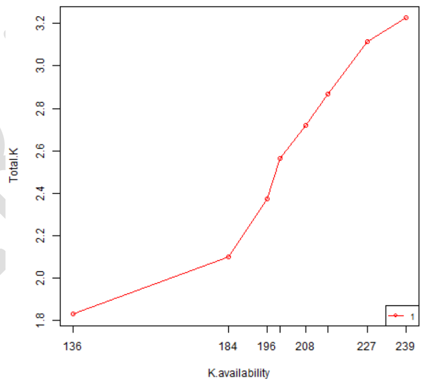

Fig.1c. Correlation of soil K availability (kg ha^{-1}) and nutrient content in small onion (R^2 = 0.939)

Fig. 1. Correlation between soil nutrient availability (NPK) and total nutrient content (NPK) of small onion.

4. CONCLUSION

The soil test based application of higher nutrient levels of NPK (125%) through TNAU-WSF increased the soil availability of NPK compared to other nutrient levels. In the case of sulphur, soil availability depends on external application of S, and soil micronutrient availability had no significant differences between means of treatment. The nutrient contents of the bulbs and leaves of small onion were highly influenced by soil available nutrients. The higher nutrient content and bulb quality of small onion were recorded with the application of higher nutrient levels (125% NPK), and they were highly correlated with soil nutrient availability.

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